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The Metamorphosis of Insects.

HALF HOURS WITH INSECTS.

1. Insects of the Garden.

ANIMAL and plant life are mutually dependent. Each has a starting point from a simple cell—"the structural unit of the entire organized world." The zoölogist and the botanist, ordinarily travelling in separate realms, seem to meet on common ground while studying the lowest representatives of their respective groups. Indeed some one has compared the animal and vegetable kingdoms to two mountain peaks of unequal height, whose adjoining bases rise from an elevated table land. The naturalist discerns below a wonderful simplicity and agreement in the scenes around him; for life is there manifested in the simplest geometrical forms, and there is no distinction between animals and plants. But as he mounts farther up one or the other of the ascents, his interest is continually excited by the numberless modifications of the simple forms beneath him, and while he finds the loftier elevation teeming with the myriad forms of animal life, yet there constantly occur to him hints and analogies connecting the most complex and highly endowed organizations with the humblest forms he left below.

The question whether animals may not be spontaneously produced still remains an open one; while the discovery of the aquarium which reveals to us the delicate balance existing between animal and vegetable life, and also the alleged necessity of the direct agency of insects in the fertilization

of many plants, are but examples of the multitudes of ways in which this dependence of plant and animal exhibits itself.

The theory of the science of agriculture, now so far perfected, seems adequate to the end. Every year adds to the perfection of the seed to be sown, as agriculturists are paying more attention than formerly to a careful selection of the best fruits and seed. The chemistry of plants, of nutrition and absorption, all the daily routine of plant life, has been mapped out by Liebig and his followers. The care of flocks and herds and their improvement have made our farmers actually better acquainted with the principles of in-and-in breeding, or the secrets of "natural selection" than many naturalists. Indeed, the facts already brought out by practical writers on this subject are important contributions towards a theory of the method and permanent effects of specific variation, a point now so interesting to naturalists.

Agricultural mechanics, in its constant endeavor to lighten toil and economize time, thus leading to the increased intelligence of the laborer, is daily enlarging its borders. New inventions of reaping and ploughing machines and labor saving machinery of every description are constantly devised, so that we may consider the theory of agricultural science far advanced toward perfection.

Now come in some disturbing agencies, such as tempests, prolonged rains, severe droughts, rust, mildew and injurious insects. Their appearance cannot be prognosticated, their direful effects once experienced cannot be immediately remedied, nor the remedies when discovered be always seasonably applied. The last mentioned cause of disturbance will now engage our attention.

Nearly every one can recall the sudden and simultaneous uprising of the army worm in New England during the summer of 1861. Its ravages have been known and dreaded yearly in the western states, where at intervals it has done wide and extensive damage. Though in a local history a

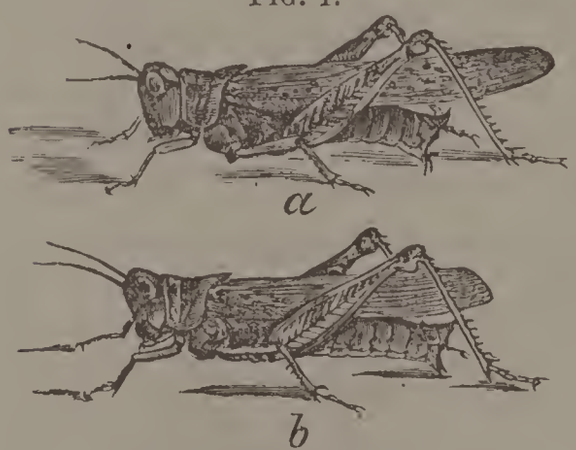
caterpillar answering to the description of the army worm had been noticed in New England at long intervals since 1743, its appearance in 1861 took all by surprise, as hosts of them appeared full grown and busy at their work, foraging upon our wheat and cereals, cutting down field after field of grain as they marched their columns in dense black masses over stone walls and through fences, often bridging ditches filled with tar or burning straw with the dead bodies of their companions; while their ranks were thinned by hosts of domestic fowls and other birds which followed hard upon their rear, or disputed their onward march. They had hardly begun their work in New York, when their appearance was heralded in the vicinity of Boston. But a few days elapsed, and their simultaneous appearance in Bangor, at the Forks of the Kennebec and the limits of civilization on the Penobscot River was announced in the papers, and the cry of their coming was caught up on the river St. John. Millions of dollars worth of grain were lost to the country by the ravages of this one species of caterpillar.

The same season the appearance of the grain aphis in hosts which blackened the tops of waving grain ripening for the harvest, was no less marvellous, as the insect had been comparatively unknown before. The range of the grain aphis was still greater than that of the army worm. Though hundreds of plant lice pitted against one army worm might produce less visible effects, yet the continual depletion by these pygmies in drawing out the sap of the grain stalk must have told upon the quality of the grain and of the seed for several years succeeding.

The strange history of the locust, its wide spread migrations, its sudden appearance and departure, the mysteries of its birthplace, the ruin consequent on its devastations, are familiar to every reader of the Bible, and are repeated in ancient and modern accounts of oriental travel. These scourges of mankind, these insect Vandals and Goths have

their family relatives in this country. Rumors are yearly heard of immense flocks of grasshoppers (Fig. 1 *a*, *Caloptenus spretus*) devastating immense tracts of soil in the farthest west and the Pacific slopes of the Rocky Mountains. In New England and the Canadas our most common grasshopper (Fig. 1 *b*, *Caloptenus femur-rubrum*) has at times emulated the bad fame of the eastern locust. In Williamson's "History of Maine," it is stated that "in 1749 and 1754 the common red-legged grasshoppers were very numerous and voracious: no vegetables escaped these greedy troops; they even devoured the potato tops; and in 1743 and 1756 they covered the whole country and threatened to devour everything green. Indeed, so great was the alarm they occasioned among the people that days of fasting and prayer were appointed, on account of the threatened calamity." Dr. Harris thus quotes from President Dwight's Travels: "Their voracity extends to almost every vegetable; even to the tobacco plant and the burdock. Nor are they confined to vegetables alone. The garments of laborers, hung up in the field while they are at work, these insects destroy in a few hours, and with the same voracity they devour the loose particles which the saw leaves upon the surface of pine boards, and which, when separated, are termed sawdust. The appearance of a board fence from which the particles had been eaten in this manner, and which I saw, was novel and singular; and seemed the result, not of the operations of the plane, but of attrition. At times, particularly a little before their disappearance, they collect in clouds, rise high in the atmosphere, and take extensive flights, of which neither the

FIG. 1.



Destructive Grasshoppers.

cause nor the direction has hitherto been discovered. I was authentically informed that some persons employed in raising the steeple of the church in Williamstown, were, while standing near the vane, covered by them, and saw, at the same time, vast swarms of them flying far above their heads. It is to be observed, however, that they customarily return and perish on the very grounds which they have ravaged." In the western plains the long-winged Caloptenus (*C. spretus*, Fig. 1 *a*) is still more destructive.

I might also cite the annual loss sustained by the attacks of the wheat midge and Hessian fly, the state of New York having lost, according to Dr. Fitch, $12,000,000 worth of wheat in one year. 100,000 bushels of wheat could be raised annually in the state of Maine if it were not for these two insects. Among the more formidable pests in the south and west are the cotton boll worm, army worm and the chinch bug, from which farmers annually lose thousands of dollars.

For the greater or less abundance of insects, as one year succeeds another, one can readily understand that the vicissitudes of the climate, the abundance of a particular kind of food, the temporary absence of parasites and external enemies are sufficient to account. But for the vast numerical increase of insects, which are ordinarily seldom observed, and whose lives at the most span but a few months or weeks, we cannot so satisfactorily account.

Moreover, there are great injuries received from the long sustained attacks, renewed annually, of insects such as the wheat fly and farm and forest insects. A late report of a committee of the French Senate, which we find translated into the "Edinburgh New Philosophical Journal," "states that the wire worm consumed £160,000 worth of corn in one department alone, and was the cause of the deficient harvests which preceded 1856. Out of 504 grains of colza gathered at hazard at Versailles, all but 296 had been rendered worthless by insects. The reduction of yield in oil

was 32.8 per cent. In Germany, according to Latreille, the larva of a species of moth (*Psilura monacha*) consumed whole forests." In Eastern Prussia, three years ago, more than 24,000,000 cubic inches of fir had to be cut down because the trees were attacked by insects.

In view of these facts let us now look at some points in the life of an insect. Though the process of building up the tissues of the body by cell growth had not been distinctly enunciated, Herold had given in the remarkable plates to his "Disquisitiones" clear representations of the gathering of the cells; and, as the result, the faint line of tissues just entering upon the threshold of life in outlines too vague to admit of a guess as to what the future animal might be. Then the division of the elongated body into distinct rings, and the gradual, though but partial, evolution of organs, when antennæ, jaws and legs are all alike to the eye of the beholder, leave it yet a question whether any further development is to be arrested here, and the creature remain the lowest of its type, or still pass on to higher grades, following unerringly the law impressed upon its being. The embryo itself sets the question at rest when it eats its way through its shell, and after devouring its former habitation, as it often does, settles down quickly upon the leaf it is born upon, and forthwith begins its riotous life.

Before Von Siebold had published his tract upon a parthenogenesis* among bees and moths, it was currently believed that the bee grub was developed into a drone, queen or neuter, according to the quality of the food or "bee bread" it was fed with. But this acute and painstaking physiologist, by the aid of intelligent and scientific bee masters in Germany, brought out these astonishing facts in the generation of insects: that the queen bee, after her marriage flight far up in the air, laid two sorts of eggs; that while some of the eggs were, *at the will* of the queen, fertilized and produced workers,

* That is, the production of young from a virgin insect.

others were deposited as barren eggs which, however, were found to hatch out drones. It is also known that one of the young worker larvæ when placed in a separate cell and fed upon a peculiar kind of bread became eventually a queen bee.

These facts give some clew to the anomalies in the generation of plant lice (Fig. 2). Bonnet ascertained that the spring brood of aphides were virgins, which throughout the summer brought forth young alive. In the fall of the year, however, winged individuals of both sexes appeared, and during the winter the species was represented by eggs.

It has since been discovered by able anatomists, with the aid of the microscope, that these spring-born aphides so wonderfully prolific, throw off from a "bud-stock," by a

FIG. 2.

Aphis or Plant Louse.

process analogous to the budding and leaving out of plants, or to the dropping off of hydroid medusæ from their polyp-stalks, whole multitudes of young plant lice, which mature rapidly without passing through the intermediate stages of egg, larval and pupal life common to most insects. As if nature, in her exceeding haste to fill up her quotas of millions of ready made sappers and miners of vegetable life for the summer campaign, had disregarded all rules in her otherwise well regulated house. In this connection we may refer to Dr. Fitch's enumeration of the number of the Cherry Aphis, produced between the 15th and 25th of June, and how these immense numbers are reduced by insect enemies :—

"This species commences to appear as soon as the leaves begin to put forth in the spring. * * * They bring forth their young alive during the continuance of warm weather. These huddle around their parents upon the under surface of the leaves as closely as they can crowd themselves; indeed they often are found two deep, a portion of the colony standing upon the backs of the others, requiring only sufficient space between them to insert their beaks into the leaves to suck their juices. The numbers which thus make out to stow themselves within a narrow compass are almost incredible. Upon the under surface of a small leaf three-fourths of an inch long and half an inch wide I have counted upon one side only of the midvein one hundred and ninety of these lice. Yet this leaf was not more densely covered than many others. The surface of a small leaf but an inch long would therefore furnish ample space to accommodate a thousand of these insects. * * * Among the cherry trees alluded to above was a row of seven young ones which had attained a height of about ten feet. By counting the number of leaves upon some of the limbs and the number of limbs upon the tree, I find a small cherry tree of the size above stated is clothed with about seventeen thousand leaves. And at the time alluded to these leaves could not have averaged less than five or six hundred lice upon each, and there were fully a third more occupying the stems and the tips of the twigs. Each of these small trees was therefore stocked with at least twelve millions of these creatures. And yet so vigilant, so sharp sighted and voracious were their enemies that at the end of a few days the whole were exterminated."

This may help us to explain why males of certain species of gall flies have never been discovered, though a German entomologist has examined over two thousand females of one species, and not a foreign element occurred in this nation of Amazons. Mr. Walsh has, however, discovered that in an American species of gall fly, the spring brood consists of

both sexes, while the autumnal brood is composed exclusively of females. Again in some species of moths where the two sexes are of equal abundance Von Siebold found that it was no unusual thing for individuals to be hatched from eggs known to be laid by a previous virgin generation.

Fairly entered upon the duties of active life the young larva is capable of doing wonders in gastro-dynamics. It would seem with most insects as if all the eating for their lives were concentrated into this stage of their existence. For there is a period coming of long cessation from activity, when, in external immobility and seeming lethargy, wonderful transformations pervade nerve and muscular tissues; a new body, wonderfully differentiated for a new existence in a far more extended sphere than formerly, is taking on its form beneath the rough and often unsightly pupa.

After the last moulting the power and desire of eating are lost, increased stores of fat are laid up for the sustenance of the pupa, and the wings and legs of the future fly are forming. The worm seeks a shelter and often spins a cocoon of silk, and there, in quiet and away from the light, its functions of animal life suspended and a very slow vegetative existence barely sustained, as a chrysalis the insect spends a portion of its life.

The knowledge of the fact that all animals pass through some sort of a metamorphosis is very recent in physiology; moreover the fact that these morphological eras in the life of an individual animal accord most unerringly with the gradation of form in the type of which it is a member, was the discovery of the eminent physiologist Von Baer. Up to this time the true significance of the luxuriance and diversity of larval forms had never seriously engaged the attention of systematists in entomology.

What can possibly be the meaning of all this putting on and taking off of caterpillar habiliments, or in other words the process of moulting, with the frequent changes in orna-

mentation, and the seeming fastidiousness and queer fancies and strange conceits of these young and giddy insects, which seem hidden and mysterious to human observation?

We can only answer that the changes in form are necessary stages in the growth of the animal, and correlated with certain habits enabling it to hold its own in the struggle for existence.

We should apply our knowledge of the larval forms of insects to the details of their classification into families and genera, constantly collating our knowledge of the immature forms with the structural variations that accompany them in the perfect state. The simple form of the caterpillar seems to be a concentration of the characters of the perfect insect, and presents easy characters by which to distinguish the minor groups; and the relative rank of the higher divisions would seem to be definitely settled only when the form and method of transformations are thoroughly known.

The pupa state is the threshold upon which the young insect pauses before it enters upon the final stage of its existence. Though called chrysalides because the pupæ of certain butterflies are gaily ornamented with golden and silvery spots, the most of them are dull and ugly. Whether it is owing to their uninteresting appearance, or the difficulty of finding them, entomologists have very generally overlooked the consideration of their forms and have underestimated the value of the differences that the pupæ of different insects present. There is in them, more than in the caterpillar, or perfected state, a constant form by which we can readily recognize the family to which they belong; and even in the slight modifications of that persistent facies together with the slight attempts at ornamentation, which Nature seems always to be striving for in the rudest of her works, the student whose mind is upon the watch for the meanings of these slight variations will be richly rewarded. Just as insects have been classified by their larval characters, which

have always agreed with those drawn from the imago, can they again be arranged in a natural method by the sole consideration of their chrysalid characters.

When the insect breaks forth from its chrysalis, we can then see how wonderfully complex is the outer crust that gives form to the creature and protects its vital parts. At first sight we see the body divided into three portions, to which naturalists give the name of head, thorax and abdomen, terms borrowed from the anatomy of man himself, and to be retained in science only until more appropriate names are suggested. It is as if we should take a wormlike, cylindrical figure consisting of successive rows of cylinders, and should constrict it in two places, thereby dividing the whole body into three sections or regions. Of these regions the first is the smallest and most unlike the two others in shape, and besides organs of special sensation is provided with chewing organs, while within is an enlarged pair of nerve knots serving as some sort of a brain, though hardly larger than those supplying the remainder of the body. This region constitutes the head.

Larger than the head, inasmuch as it is to support the organs of locomotion, is the middle region or thorax, which supports the legs and two pairs of wings; while the largest portion of the body is the bulky abdomen, which retains very much of the original wormlike form of the larva, and is the seat of the reproductive system. But were the contour of the rings that make up these sections of the hard outer crust still continuous and unbroken, we should have the poor victims enclosed in jackets of the straitest kind. Whence comes then all the grace and freedom of action that the butterfly and ichneumon-fly possess? It is in the fact that the whole outer crust is subdivided into portions finely hinged together by tough membranes, and forming points of attachment to thousands of little muscular fibres within, thus giving it a surprising degree of flexibility. Besides these

pieces, of which there is a definite number to each of the thirteen segments or rings that compose the body of every insect, exclusive of the head, which is supposed to consist theoretically of four segments, we have to consider the numerous joints of the antennæ, of the mouth parts which consist of three pairs of appendages, and of the legs. We see therefore that descriptive entomology has to take account of several hundred distinct pieces, which by changes in their relative size and position produce the immense range of variation in the half a million species which are found living or dead upon the earth. Thus the idea of articulation upon which Cuvier founded this branch of the animal kingdom, which begins so simply in the worm and grows more complex in the crab and its allies, in the insect is carried out with a richness and profusion of detail that is almost bewildering. It is like comparing a boat dug out of a log to the Great Eastern, or an Indian's wigwam to the cathedral of Milan.

Our frontispiece conveys an idea of the metamorphosis of a butterfly, a moth and a beetle. The butterfly is the pretty *Melitæa Phaeton*, which flies in June and July. Its caterpillar feeds on the golden rod, and when it transforms into the pretty white chrysalis, fastens itself by the tail to the stem of the plant and hangs head downwards, awaiting its final change into the butterfly.

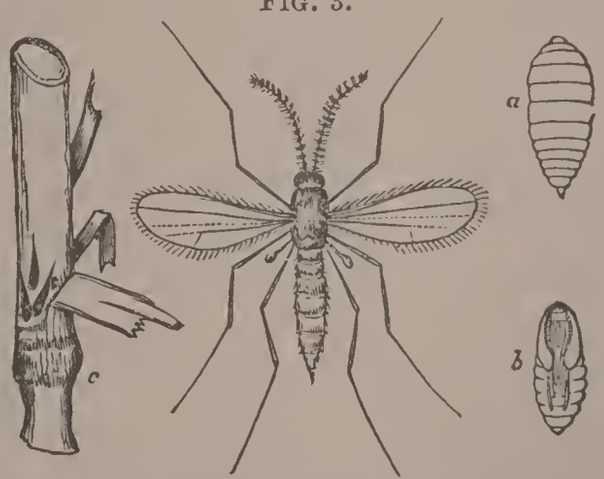
The moth whose transformations are represented on the left of the plate, is the *Ctenucha Virginica*. It is a dark blue insect which flies in the hottest sunshine, contrary to the habits of the majority of moths. Its caterpillar, which feeds on grass, is like the Hairy Bear of our gardens, and constructs under stones a pretty cocoon of hairs which it plucks from its own body.

The water beetle is the common Gyrinus or whirligig beetle, so commonly seen gyrating in small parties over the surface of our ponds. Its singular larva is long and slender, with long fringed breathing appendages along the sides of the body.

After all the insects interest us most when we study their psychology and habits. From what little we know of their psychical endowments, we see enough to convince us that as physically they occupy a middle ground between ourselves and the lowest and simplest of animals, so in their instincts they seem to maintain a corresponding relation. They have, what is the common property of all animals, enough intelligence to meet the exigencies of life. They possess apparently like passions with ourselves, so much so that we find ourselves unconsciously judging of their actions by our own feelings. Hence to our senses they hate and love, show fear and revenge, enjoy their moments of repose from toil, engage in sports, carry on wars, live a hermit life or are gathered into commonwealths, and are capable, individually, of some degree of education.

All this great diversity among insects in form and accompanying adaptation of instinct and reason are subservient to the part these animals are to play in nature. There are no neutral, non-committal characters among insects. The agriculturist classifies them into two categories, the friends and foes of his crops—according as they are carnivorous or herbivorous; and it is necessary for him to distinguish carefully between them. This is often a difficult matter, for as we descend in the scale of animal life we find those broad lines of demarcation which separate animals of different habits growing less distinct. In some tribes which resemble each other so closely that only educated eyes can distinguish them, we have species of totally different habits. Thus the Hessian fly (Fig. 3)

FIG. 3.



Hessian Fly: *a*, larva; *b*, pupa.

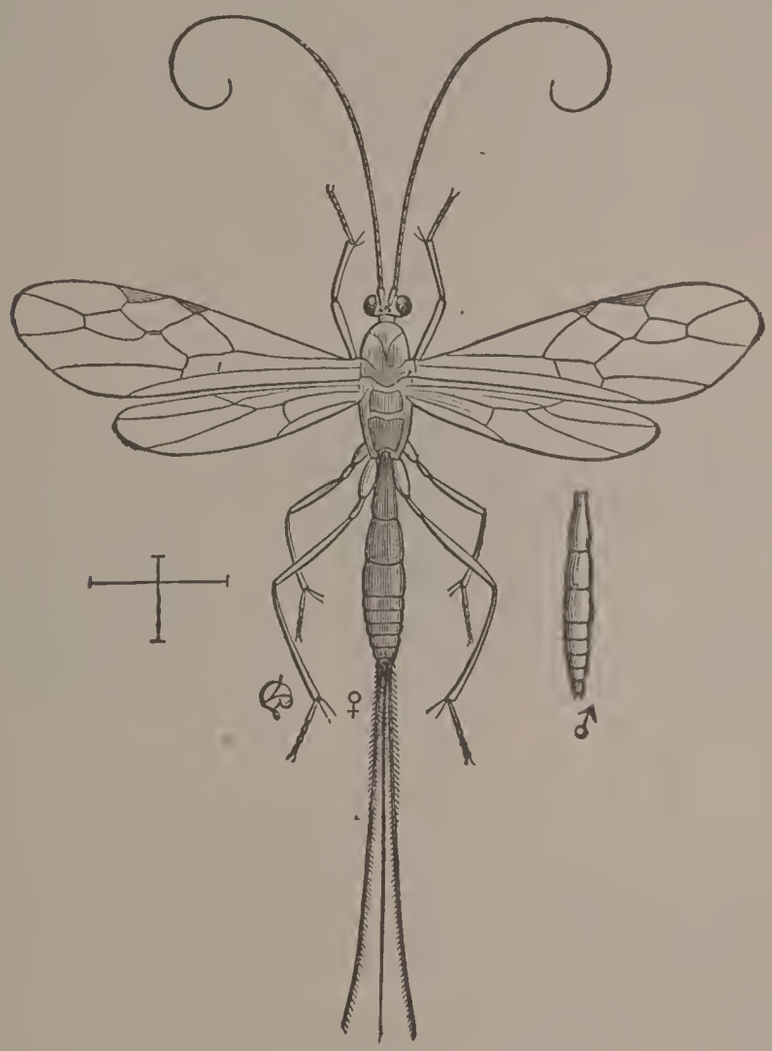
which swarms over our wheat-field might easily be mistaken by the farmer for what seems to him to be merely small or "young" mosquitoes, so similar are the mature stages of the two: though when a larva the one preys upon our crops, and the other does service to mankind as a scavenger of our ponds and pools. So also the bed bug, which we can with safety pronounce to be essentially a blood-sucker, has many allies which are innocuous sap-suckers. Indeed our wonder is continually excited at finding insects of very similar form with habits of life most strikingly opposed.

Any account of the natural history of an insect would be very imperfect, were the habits and description of the peculiar parasites that check the increase and diffusion of the species left unrecorded. All animals and many trees and plants are exposed to annoyance from the continued attacks of other species, without having their actual existence endangered; but among insects the term parasitism has another and extraordinary meaning; since besides those minute forms of lowly organized life which only harass without inflicting more serious injury, we have an immense number of insects high in the scale of organization, which subsist upon other insects only to kill and destroy them utterly. Thus of the ordinary parasitic plants and animals which always live on insects Dr. Leidy has given us in his "Flora and Fauna within Living Animals" published in the "Smithsonian Contributions to Knowledge," some representations, of remarkable delicacy and beauty, of miniature forests of microscopic plants which line the alimentary canal of several sorts of ground-inhabiting insects. There are not wanting here even divers sorts of low and exceedingly minute worms, part of whose office it may be is to restrain and keep within bounds the vegetation which luxuriates in those strange passage ways.

In the other form of parasitism the insect devours all the soft parts of the body of its victim, leaving but the empty

crust in its place. Now there are two conditions to be fulfilled in this act of parasitism; for the insect preyed upon must maintain its hold upon life, feeble as it may be, long enough to enable the enemy lurking within, to build up its tissues and add to its own strength by daily depleting from

FIG. 4.



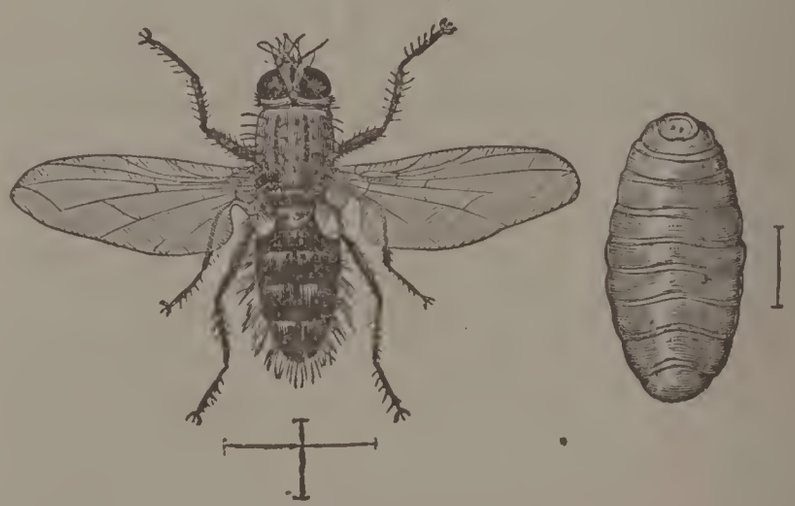
Ichneumon (Macrocentrus).

the stores of vitalized food about it; and on the other hand the parasite must carefully avoid touching the vital parts of its host. It must content itself with feeding upon the fatty portions alone of the body.

That family of the Hymenoptera of which the ichneumon-fly (Fig. 4) is a type, and many species of true flies

(Fig. 5) bearing a close resemblance to the common house-fly, are devoted to this work of parasitism-extraordinary. The process is thus: the parent fly lays its eggs within or upon the body of its victim, most commonly a caterpillar which is full-grown and about to enter upon its transformations. The young worm hatches and feeds upon the large stores of fatty tissues which surround the vital organs of its host. How very nice must be the adjustment of relations between the two animals, when in the case of the parasite, the slightest deviation from its path involving any injury to the neighboring nerves or vessels of its host will bring

FIG. 5.



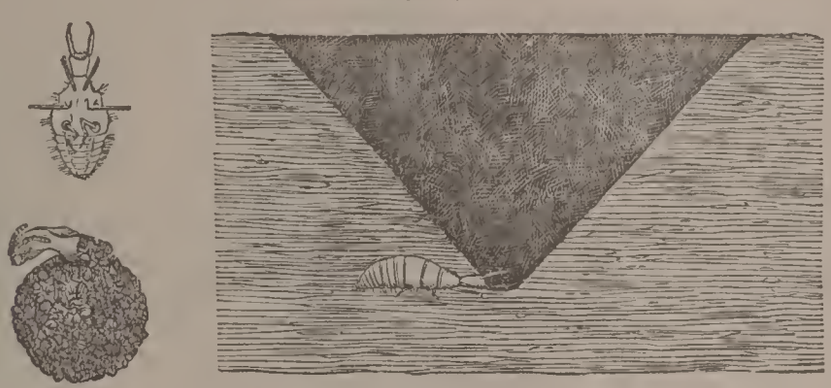
Tachina and larva.

eventual ruin to itself by hastening the death of the caterpillar! This delicate balance between the growing parasite and wasting victim may continue through the chrysalid state of both insects, until just as we think the butterfly will break its prison walls, lo! the trim, neat form of its unrelenting enemy steps forth from its body ready armed and equipped for active service.

The late Mr. Herrick some years ago announced the discovery of the fact that the eggs of the canker worm were preyed upon by a minute ichneumon-fly. Here is an anomaly—an egg nourishing its inhabitant and immersed in the

contents of another egg! We have had the pleasure of watching the labors, late in autumn, of this little insect, whose length measures not over three hundredths of an inch, as it was busily engaged upon a bunch of eggs under our object glass, with a restless anxiety to rid itself of its burden of infinitesimal eggs by pushing them through the walls of those upon which it stood. Each egg developing perhaps simultaneously, we can imagine the race and struggle for existence in that tiny enclosure. The germ of the larger worm rapidly collects and arranges the elements of its own form, but it is in vain; for the smaller being of a more rapid growth is stealthily and unawares as constantly pulling

FIG. 6.



Ant-lion.

down that structure of cells and tissues. The race is not always to the strong.

It often happens that several species of these parasites feed upon a single kind of caterpillar. Thus upon the army worm six species of ichneumons are known to exist, and a Tachina fly is extremely destructive to it. Baron Humboldt tells us in the "Views of Nature" that "Bombyx Pini, the Pine Spinner, the most destructive of all the forest insects in Europe, is infested, according to Ratzeburg, by no less than thirty-five species of parasitical Ichneumonidæ."

We have incidentally alluded to the agency of carnivorous insects in diminishing the numbers of vegetable feeders. The appellation of ant-lions (Fig. 6, ant-lion in its hole;

Fig. 7, adult), aphis-lions, tiger beetles, water tigers (Fig. 8) and dragon-flies, names borrowed from their fierce four-footed namesakes, are significant of the fierce passions and insatiable appetites of their six-footed copyists.

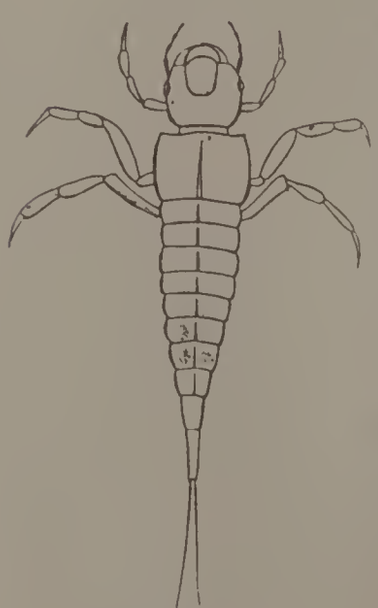
We were one autumn reminded of the great value of having

FIG. 7.

Ant-lion, adult.

a brood of martins or swallows about the farm and garden, when a storm prostrated a martin box, and one of its compartments was found literally packed with the dried remains of the little yellow and black squash beetle. The great and efficient aid of birds is too apparent to be passed over lightly. We quote again from the Report of the French Commissioners upon this subject. "The commission excludes birds of prey, such as magpies, ravens, etc., with the exception of buzzards and rooks, from the benefit of its protection, because the buzzard consumes about six thousand mice yearly. The rooks eat an incalculable amount of white worms. Sparrows, once thought harmful as eating grain, are restored and their usefulness shown by reference

FIG. 8.



Water Tiger.

to the fact, that when their destruction was attempted in Hungary, winged insects increased so rapidly that rewards for the destruction of sparrows were suppressed, and others given for bringing them back.

"Frederick the Great ordered the destruction of sparrows because they ate his cherries, but in two years' time he found his cherries and all other fruits consumed by caterpillars. In a sparrow's nest on a terrace in the Rue Vivienne were found the remains of seven hundred cockchafers. Owls and birds of that class which agricultural ignorance pursues as birds of ill omen ought to be welcomed. They are ten times more useful than the best cats, and not dangerous to the larder. The martins that were killed, were found to have in their stomachs the remains of five hundred and forty three insects. The commission recommended a prohibition of bird-nesting and the destruction of eggs or young birds." We must not kill any birds: even those that in the late summer pilfer from our orchards, at other times eat multitudes of worms. It will not do to destroy the balance of nature.

The study of insects has been too much confined to their classification and the synonymy of the species. It is only occasionally that we see naturalists whose dispositions and opportunities lead them to study habits exclusively, or to combine the two departments of study. DeGeer and Reaumur of the last century, whose ponderous tomes are packed with observations of insect economy, many of which have never since been repeated, laid the foundation of these inquiries. The labors of the Swedish Count and French natural philosopher are monuments of patient research and curious inquiry.

Here also should be noticed Ratzeburg's great work on forest insects. In the elaborate and beautiful plates, fifty-seven in all, that enrich the two volumes of this distinguished entomologist, is reproduced the tree as it stands

in the forest, gnarled and distorted by one set of insects, its leaves curled and turned yellow or red by the attacks of others, with certain branches stripped by still others; and not only are certain trees and shrubs thus represented in colors, but some of the plates represent parts of a forest, showing the injury done in the mass by one or two species of insects, with the changes in the form of branches and leaves for several years succeeding the defoliation, and the after growth of branches depending on the different degrees of injury, with transverse sections of the twigs, and microscopic sections illustrating the pathological anatomy of the tree. In England Curtis' "Farm Insects" and in our own country Harris' Treatise on the Injurious Insects of Massachusetts, together with Fitch's reports on the injurious insects of New York, and Walsh's on those of Illinois, Riley's on those of Missouri, LeBaron's on those of Illinois, Trimble's work on the insects injurious to fruit trees, and the reports of the writer on the insects of Massachusetts, all elucidate the subject of applied or economic entomology.

Indeed the study of economical entomology is of growing importance. Every passing year witnesses the attacks of new enemies of our crop that appear as the forests are cut down, and their natural food plants destroyed. The wanton killing of insect-eating birds also tends to a steady increase in the number of noxious insects. More knowledge of entomology should be diffused among agriculturists, that they may be made acquainted with these pests and be forewarned against their attacks and thus save a fair percentage of their crops.

We begin in this number an account of the insects of the garden, and as their name is legion we shall have to select a few of the most noxious, and portray as clearly as possible their forms, and briefly sketch their habits.

Were we to enumerate all the insect pests which gather about our flowers, garden vegetables, ornamental shrubs

and fruit trees, the list would extend to several hundreds. A few of these, such as the imported cabbage butterfly, apple bark-louse, the vaporer moth, the gooseberry saw-fly and others are importations from Europe, while the still more injurious canker worm, tent caterpillar, apple tree borer, pear slug, and more that could be mentioned are natives, and before the apple and pear were introduced probably fed on the species of wild cherry, thorn and other rosaceous plants common in our woodlands.

In speaking of the great number of injurious insects which infest certain plants, I may be pardoned for quoting as follows from my first "Annual Report on the Injurious and Beneficial Insects" made to the Massachusetts Board of Agriculture.

"We should not forget that each fruit or shade tree, garden shrub or vegetable, has a host of insects peculiar to it, and which year after year renew their attacks. I could enumerate upwards of fifty species of insects which prey upon cereals and grasses, and as many which infest our field crops. Some thirty well known species ravage our garden vegetables. There are nearly fifty species which attack the grape vine, and their number is rapidly increasing. About seventy-five species make their annual onset upon the apple tree, and nearly an equal number may be found upon the plum, pear, peach and cherry. Among our shade trees, over fifty species infest the oak; twenty-five the elm; seventy-five the walnut, and over one hundred species of insects prey upon the pine."

Cut Worms.—Among those general pests, which have no special food-plant, and from their omnivorous tastes do infinite mischief in gardens, are certain sly, nocturnal creatures, the cut worms. They have the well known habit of cutting off with their jaws the young, succulent plants of the cabbage, turnip, bean, tomato, corn and various cultivated flowers.

These caterpillars are usually cylindrical, the body taper-

ing slightly towards each end, with a horny crescent-shaped plate on the segment preceding the head. They are usually livid greenish, or ash gray, with darker stripes along the body, which is either smooth or slightly warty. At rest they may be found curled up under sticks or stones in the grass, or under boards, etc., left carelessly in the garden. They transform within a rude earthen cocoon or chamber under the ground, into a brown chrysalis which may often be found at the roots of corn, grass, etc. The worm may be found late in spring and early in summer. The parent moths fly late in summer and in September, and while most of the family (Noctuidæ) fly only by night, these Dart Moths, as they are called, from their rapid, headlong flight, may be seen in the hottest days about the flowers of the golden rod.

FIG. 9.

Gothic Dart Moth.

Our commonest species is the Gothic Dart Moth (*Agrotis subgothica* Fig. 9). The young of this modest moth is said by Mr. Riley, who has reared it, to be an inch and a quarter long, of a dirty white or ash gray, with sometimes a yellowish tinge. Along the back is a whitish line, edged on each side with a dark one. On the side are three lateral dark broader stripes, the lower one the widest.

Another common, but still larger, Dart Moth is the Lance Bearer, *Agrotis suffusa* of European authors, or *A. telifera* of Harris (Fig. 10). Mr. Riley calls its caterpillar the "Large Black Cut Worm." It is an inch and a half long, dull brown above, with a distinct pale line on each side of the middle of the back. Between these lines and the row

of breathing holes are two more pale lines. There are eight black shining minute warts on each segment, each wart bearing a short hair.

A third species of cut worm, whose parent was called by Harris the Clandestine Moth (*Noctua clandestina*), is next to the Gothic Dart Moth, our most common species and may be found by day hiding under boards, etc. It flies only by night. It is a blackish moth with obscure markings. Its caterpillar is called by Riley the W-marked Cut Worm. It is an inch and an eighth long, and is "ash gray, inclining on the back and upper sides to dirty yellow; it is speckled all over with black and brown spots." He adds, that besides the usual lines on the side, "the distinguishing feature is a row of black velvety marks along each side of the back, on all but the thoracic segments [*i. e.*, the three succeeding the head] bearing a general resemblance (looking from tail to head) to the letter W."

FIG. 10.

Lance Bearer.

FIG. 11.

Cochrane's Dart Moth.

These may be regarded as examples of the group of cut worms, of which we have numerous forms. All, however, seem to agree in the special mode of attack. They cut young plants square off, near the ground, and then luxuriate on the soft pulpy centre of the stalk. One species in the west (*Agrotis Cochrani*, Fig. 11) ascends pear and apple trees

and grape vines, eating off the fruit buds; while another larva, not of a true Agrotis however, in New England cuts off the soft fresh shoots of the currant.

Mr. Cochrane says that the western moth always prefers "to lay her eggs near the hill or mound over the roots of the trees in the orchard and if, as is many times the case, the trees have a spring dressing of lime or ashes with the view of preventing the operations of the May Beetles, this will be selected with unerring instinct by the miller, thus giving her larvæ a fine warm bed to cover themselves with during the day from the observation of their enemies." It is probable that the females of all the Dart Moths deposit their eggs at the roots of grass, stubble, etc., in the summer and early autumn, and sometimes in the spring. It is a weighty reason for burning all stubble or ploughing it under as deeply as possible, that the eggs of many insects and indeed various insects themselves are thus destroyed. Nearly all these moths frequent grass lands, and rise from the ground on being disturbed, fly off in their headlong course a few yards and drop down towards the roots of the grass.

According to Riley the eggs hatch out, and the larvæ acquire two-thirds their size when winter overtakes them; they then descend below the reach of the frost, there remaining torpid until the warmth of spring calls them to the surface. In a few species the winter is passed in the chrysalis state.

Cut worms hide by day under stones, boards or sticks, or in gardens burrow into the dirt to avoid the light and heat. At dark they come up to the surface and usually, according to Mr. Coleman ("American Naturalist," June, 1873), appear regularly, those that he watched coming up at nine o'clock. He observed that the worm fed upon the grape in the following manner. "The worm would come out of the ground at its usual time, ascend the vine till it came to a new shoot,

gnaw that off and fasten itself to the stump of the branch so gnawed and suck the sap of the vine till it was so full that it seemed almost ready to burst, then descend to the ground and bury itself out of sight."

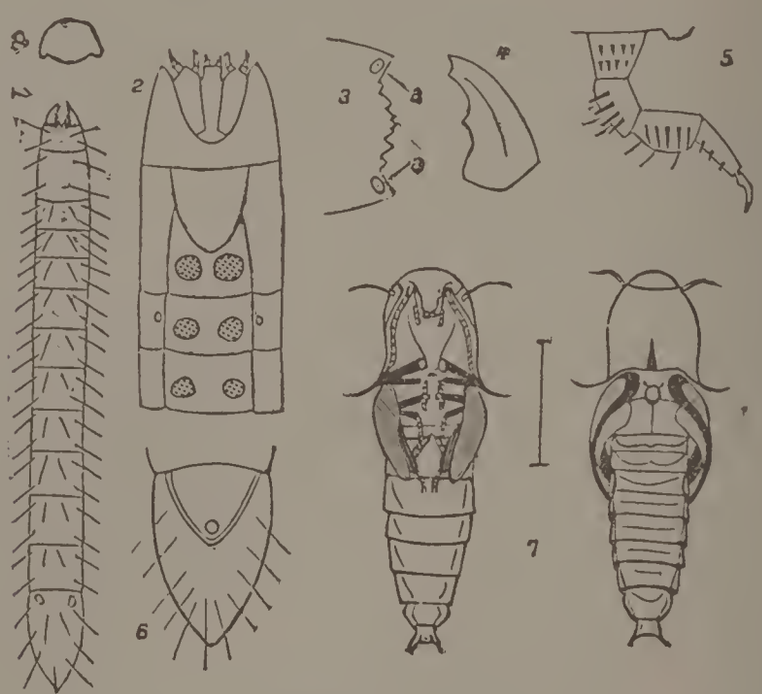
It is well known that a roll of paper or tin surrounding the plant and its roots is the best preventive against the insidious attacks of the cut worm. Mr. Cochrane in dealing with the Apple-bud Cut Worm says, "there is no known remedy, salt has no properties repulsive to them; they burrow in it equally as quick as in lime or ashes. Tobacco, soap and other diluted washes do not even provoke them; but a tin tube, six inches in length, opened on one side and closed around the base of the tree, fitting close and entering at the lower end an inch into the earth, is what the lawyers would term 'an effectual estoppel' to further proceedings."

The best remedy is, then, to watch for the worms at dark or dig around the roots by day and kill by pressure under foot. The next best remedy is to surround the plant with a roll of paper or pasteboard, and avoid the use of nostrums recommended to kill the worm. It is also a good plan to set boards under which the worms are inclined to hide; they should be examined every day and the worms if found killed. Riley suggests that many cut worms may be entrapped by making smooth holes with a stick and examining them the next day, when the worms may possibly be found at the bottom.

The Wire Worm.—Another universal plague in gardens is the wire worm. It is omnivorous in its tastes, feeding on the roots of grain, lawn grass, various flowers and vegetables, and in some cases attacking fruits and flowers. They occur in all sorts of places, but more abundantly than elsewhere under the bark of trees and stumps, where they feed on the decaying wood and thus are not harmful. We have between one and two hundred species in this country. The

accompanying figure* (12) taken from the Report of the Entomological Society of Ontario, Canada, for 1871, represents the larva and pupa of a common form (*Agriotes mancus*) which is very injurious to wheat. The wire worm is readily known by its smooth, slightly flattened cylindrical hard reddish body. Mr. Johnson Pettit, who has made us fully acquainted with the habits of the wheat wire worm, says that it lives three years in the larval state. He obtained a knowledge of its habits by planting wheat in flower pots. He

FIG. 12.



Wheat Wire Worm.

found the grubs in the autumn, "with the first cold weather they ceased to eat and were then placed in a sheltered situation until the return of warm weather in the spring, when they were restored to the breeding cages. They soon gave evidence of being alive and possessing unimpaired appetites;

*1. Larva, enlarged a little over three times, *a*, a transverse section. 2. Under side of the head and three succeeding segments. 3. Margin of the front; *a*, position of the antennæ. 4. Mandibles. 5. Legs. 6. Under side of the last segment of the body. 7. Upper and under side of the pupa, the line between representing the actual length (after Horn).

their rapid consumption of the wheat plants rendered it necessary to renew the supply quite as often as before. They were fed in this way until the month of July. On the 26th of August one of the grubs changed into a pupa and on the 3rd of September the first beetle appeared. It is a pale reddish brown insect. This insect and its allies are called click or snapping beetles from their power of throwing themselves up in the air in order to right themselves whenever placed by accident on their backs.

Fig. 13.

Snapping Beetle and larva.

Figure 13 represents the grub and beetle of another wire worm which, according to Mr. Walsh, lived in decaying wood in his breeding jar for a period of two years. Figure 14 (enlarged four times) represents a small slender wire worm found by Mr. Sanborn in the roots of the squash vine. Another form (Fig. 15 enlarged twice) is a common wire worm in the northern states. Allied to the northern elaters, or snapping beetles, is the Cuban fire fly (Fig. 16) which has two large luminous eye-like spots on each side of the thorax, and another at the base of the hind body beneath. We have, in New England even, a phosphorescent wire worm (Fig. 17, Melanactes) which sends out a dull greenish light at night.

Fig. 14.

Wire Worm.

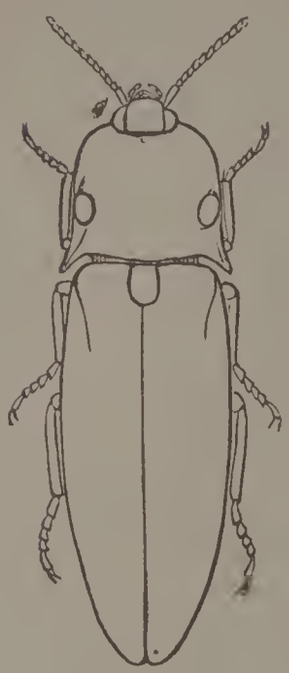
Fig. 15.

Wire Worm.

We cannot, in speaking of remedies, do better than quote from Mr. Bethune's report. "Lime and soot, to be applied to the soil before sowing any grain, are highly recommended by some, but are of doubtful efficacy.

Salt on sandy soils is considered to be efficacious, but not on heavier clay lands. In a garden or small field they may be got rid of by strewing about slices of potato, turnip or apple, and examining the under sides every morning, when numbers will usually be found feeding upon the bait.

FIG. 16.



Fire Fly.

Moles are very useful in destroying them in meadows, and a large number of our small birds devour them with avidity; ducks, turkeys and fowls will pick them up in ploughed fields, and toads are not averse to making a meal upon them. Our advice then is, break up and fallow the infested wheatfields, ploughing often, and burning up the rubbish; and encourage in every way the farmer's best friends, the small birds. Make it an absolute law of the household that not one of them is to be shot or stoned, get your neighbors to do the same, and believe us, not many years will pass before you will find your insect plagues enormously diminished." The concluding remarks apply with much force in dealing with all our noxious insects.

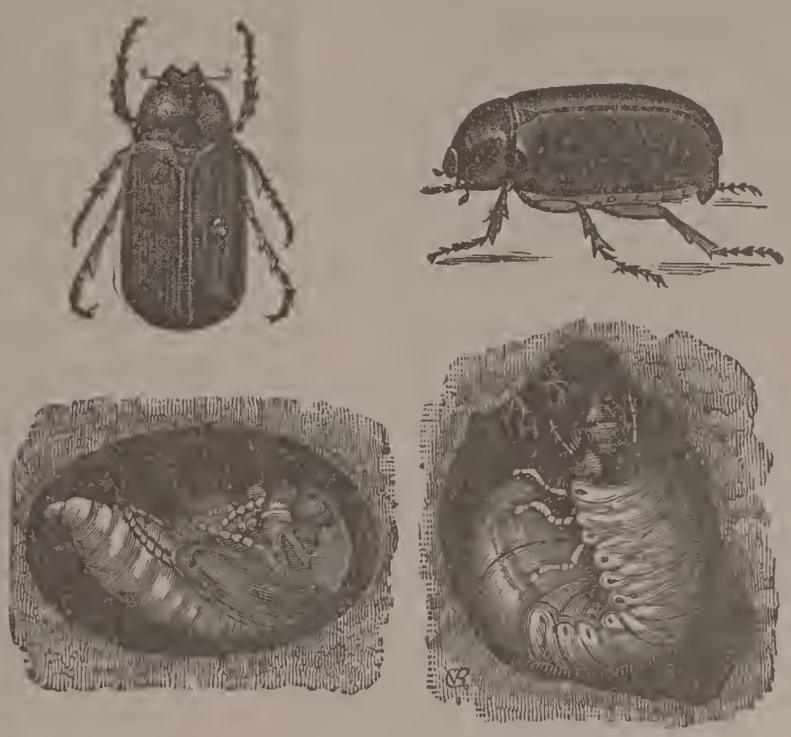
FIG. 17.

Luminous Wire Worm

The May Beetle.—(Fig. 18, larva, pupa and beetle, after Riley.) Our readers may recognize old acquaintances in the insects here figured. The grub or white worm is abundant in gardens, lawns and grass lands, and the parent beetle or Dor-bug is the insect which so pertinaciously taps against our windows at night, and if successful in effecting an entrance, wheels its "droning flight" about the room to the terror and confusion of those within. The grub is a large, soft-bodied, fleshy, white worm, as thick as the little finger, about an inch and a half long, with a honey-yellowish or pale horn-colored head. Its skin is so thin and trans-

parent that the air vessels and viscera can be seen through it, and though it has three pairs of rather long legs, it is so

FIG. 18.



May Beetle and young.

gross and unwieldy that it lies flat on its side when dug out of its retreat in the soil.

In this state the grub lives three years. The series of changes the insect passes through in its whole existence is as follows: in the months of May or June the beetles pair, and the females lay from forty to fifty eggs in loose dirt below the surface. These eggs, according to Mr. Riley, hatch in the course of a month, and he adds that the grubs growing slowly, do not "attain full size till the early spring of the third year, when they construct an ovoid chamber lined with a gelatinous fluid." This fluid hardens, we may add, forming a glazed inner wall. The chrysalis, or pupa (Fig. 19), may be found in these cells about six inches under the surface in May, and rarely in the autumn.

FIG. 19.

Pupa of May Beetle.

During the latter part of May and early in June in New England, namely, for about a month, the beetle flies about at night, being most active in warm, damp weather, especially before thunder storms, a period when most insects are restless.

By day our beetle in its sober garb of chestnut-brown hides in the foliage of trees, especially the apple, clinging to the under side of the leaves by its long curved claws, which are admirably adapted for the purpose. During winter the grub descends below the reach of frost, and at the approach of warm spring weather wriggles up towards the surface.

The European Cockchafer has much the same habits as our May-chafer, and when we say that in 1866 the grubs of the Cockchafer destroyed in the department of the lower Seine over $5,000,000 worth of garden vegetables, we fear we are prophesying a state of things that may ensue in America when our population becomes as densely crowded as in the old countries of Europe.

M. Reiset (see "American Naturalist," vol. ii, 209) says that this insect is three years in arriving at its perfect beetle state. The larvæ (grubs) hatched from eggs laid by the beetles which appeared in 1865 passed a second winter, that of 1867, at a mean depth in the soil of nearly a foot and a half. The thermometer placed in the ground (which was covered with snow) at this mean depth never rose to the zero point (or 32° Fahr.) of the Centigrade thermometer, as *minimum*. Thus the larvæ survived after being perfectly frozen (probably most subterranean larvæ are thus frozen and thawed out in the spring). "In June, 1867, the grubs having become full-fed, made their way upwards to a mean distance of about thirteen inches below the surface, where, in less than two months, they all changed to the pupa state, and in October and November the perfect beetle appeared. * * * * The immature larvæ, warned by the approaching cold, began to migrate deep down in the soil in October,

when the temperature of the earth was ten degrees above zero (Centigrade); as soon as the snow melted they gradually rose towards the surface."

The mischief done by the grub of the May beetle is at times almost incalculable. In lawns and grass lands it eats the roots of grass. Dr. Harris, in his well known Treatise, says that "in many places the turf may be turned up like a carpet in consequence of the destruction of the roots." We have lately ascertained that it seriously damages strawberry plants, being undoubtedly introduced in the manure. It eats the main roots, and so large and voracious is this worm that the roots of one plant must form a light meal for them, and a dozen or so of the worms would be enough to ruin a small bed of strawberry plants. It is obvious, then, that if we observe a plant to wilt and suddenly die, the "white worm" is at the roots. It should be dug up, and crushed beneath the foot. It also eats, in a still more summary manner, young squash plants, when they have thrown out three or four leaves, so that gardeners have been obliged to plant the seed over once or twice.

FIG. 20.

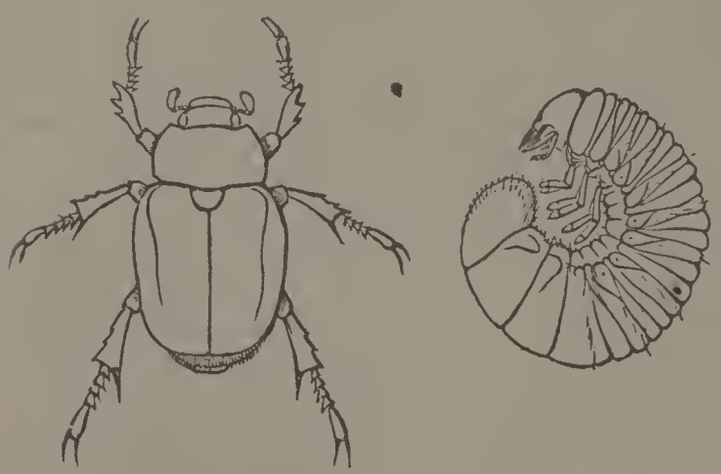
Calosoma calidum.

As to remedies against this grub, the careful gardener will in the first place destroy every grub turned up by the plough or spade. When the top dressing is spread over the bed, he would do well to examine it carefully for these conspicuous worms. When a vine is seen to die down suddenly in summer he must then dig around the roots and search for the aggressor. It is better to spend much time and money for two or three years in succession in endeavoring to exterminate these grubs than to yield passively to the scourge. It is well known that crows and small birds feed upon them in corn fields. Skunks and moles are efficient aids in killing both grubs and beetles, and the larger carnivorous beetles, such as the Calosoma (Fig.

20), devour the beetle itself. In certain favorable years the May beetle is fearfully abundant. It is then necessary to resort to hand picking. If the French take the pains to practise picking their chafers off the plants by hand, so that in one instance about 80,000,000 were collected and destroyed in a single portion of the department of the Lower Seine, our gardeners can afford to take similar care.

The Goldsmith Beetle (Fig. 21).—Of very similar habits is an ally of the May beetle, the beautiful woolly yellow beetle, which is as varied in its tastes as the May beetle. The insect in the beetle state feeds on the young, tender leaves of the pear, elm, hickory, poplar, oak, sweet gum and blackberry; while the grub does much mischief to the roots of strawberry plants. The grub is white, with a yellowish head, and closely resembles that of the May Beetle, simply differing in having longer antennæ and feet.

FIG. 21.



Goldsmith Beetle and larva.

Rev. Dr. Lockwood has made us acquainted with the habits of this destructive chafer. In the middle of June in New Jersey the beetle lays in the night about fourteen eggs in the soil, each egg being deposited singly and at different depths. In about a month, *i. e.*, the middle of July, they hatch. In other respects its habits are much as in the May beetle. In one instance two acres of plants were "irretrievably ruined." Dr. Lockwood adds that "the Goldsmith grub can be taken at any hour of the day simply by scratching the earth from around the roots of those plants whose dark, shrivelled leaves tell of the enemy's presence.

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